Project AIR FORCE
Research Brief

Jet Engine Intermediate Maintenance for Expeditionary Operations

The Jet Engine Intermediate Maintenance (JEIM) shop traditionally has been located with the fighter unit it supports. Expeditionary requirements for quick deployment have led the U.S. Air Force to consider whether intermediate maintenance ought to be centralized. Besides expeditionary operations, current factors favoring centralization are the increasing technical complexity of engines, potential gains from economies of scale, and changes in experience levels of technicians. On the other hand, the issue of control over maintenance assets and the potential of having advanced engines subject to technical repair orders that require immediate attention favor the current decentralized maintenance structure.

In operations against Serbia in 1999, logisticians established centralized engine repair facilities at European bases to support forces deploying to new operating locations or those with limited facilities. This experience and the emerging support requirements of the Expeditionary Aerospace Force led the Air Combat Command and the Air Force Deputy Chief of Staff for Installations and Logistics to ask RAND for analysis of centralized and decentralized JEIM options for expeditionary support.

Simulating System Performance

The study team evaluated five alternative structures for supporting forces deployed to a notional 100-day major theater war:

- *Decentralized-Deployed (DecDep).* JEIM support is decentralized with each base having its own capabilities in peacetime. Part of each base's JEIM deploys with the aircraft to a forward operating location (FOL) in war.
- *Decentralized-No Deployment (Home).* JEIM support is decentralized with each base having its own capabilities in peace and war, and supporting deployed aircraft from home during war.
- *Decentralized-Forward Support Location (FSL).* JEIM support is decentralized during peacetime. During war, a single JEIM shop is set up in the theater, within two days (one-way) transportation time to operating locations, to support all deployed units with a given type of engine.
- *CONUS Support Location (CSL)-FSL.* A single centralized JEIM in the continental United States (CONUS) supports all units in peacetime. During war, CSL personnel deploy to a theater FSL to support deployed units. In the theater, performance for this alternative is identical to the previous one.
- *CSL.* A single CSL supports all units in peace and war.

Because none of these alternatives has been implemented for an entire engine fleet or used in a major theater war, the study team developed a simulation model of centralized and decentralized JEIM operation. (Although most previous RAND work on supporting expeditionary aerospace force operations has used deterministic models, a simulation model was used here because it is best for analyzing inherently dynamic processes such as engine repair, the demand for which varies greatly with the conduct of a war.)

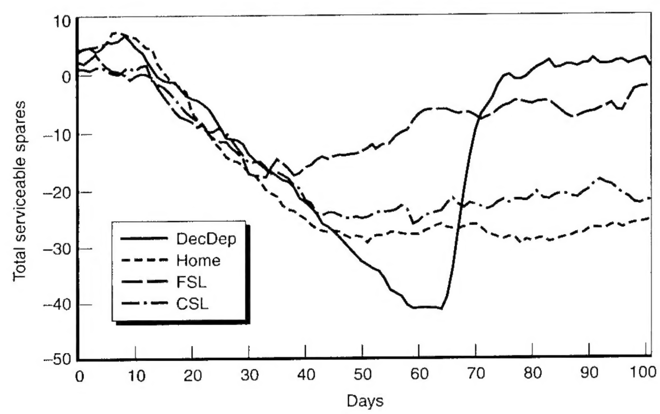
The researchers developed models for three engines: the Pratt & Whitney F100-220 and F100-229 engines used on F-15 and F-16 aircraft, and the General Electric TF-34 engine used on A-10 aircraft. The analysis featured a simulated 100-day major theater war following a year of peace, after which planes returned to their peacetime flying schedules. Simulated use and removal rates were based on historical data and planning recommendations.

To compare personnel, equipment, and transportation requirements for each option, the team calculated levels of repair capacity needed to ensure that no sorties were missed during the simulated war. These also suffice to meet peacetime requirements.

Maintaining Sufficient Spare Engines

The key point of comparison for each repair structure is its performance in maintaining daily spares levels throughout the simulated war. The figure shows the daily number of available spares for four maintenance structures of F100-220 engines on F-16 aircraft. Deploying the

JEIM as in the Decentralized-Deployed structure gives the worst performance in terms of spares: At day 60, deployed forces are short more than 40 engines, meaning more than 40 aircraft are not mission capable because they have no operating engines. This result is largely because of the time it takes to construct a test cell at an unprepared site. Once the test cell is operational, deployed support quickly recovers and provides marginally more spares than its alternatives, but at a cost of twice as much personnel and equipment than is needed for the centralized alternatives. While available spare engines decline for all options throughout the first thirty days of the war, those for an FSL system stabilize and gradually improve after day 30 of the simulated war.



Spare Engine Availability for Repair Structures Serving F-16 Aircraft Using F100-220 Engines in a Simulated Major Theater War

In exchange for lower equipment needs, centralized options require dedicated and responsive transportation to move unserviceable engines to the repair facility and repaired engines back to the bases. Centralized system performance is quite sensitive to deviations from times used in the modeling. Researchers assumed that transportation of engines between a support and operating location would require two to four days; even a small increase in this transportation time would result in missed combat sorties. A centralized structure is, however, better able to adapt to changes in removal rates or other scenario changes.

Deploying *all* spare engines in the simulation, and not just those set aside for war reserve, cuts the spares deficit of deployed support. However, deployed support would still have a negative number of spares and there would be no spares available for other purposes (e.g., training). The low number of war reserve engines also affects how other systems in the analysis perform. Indeed, the research indicates that the number of engines set aside for war reserve may be too low.

In addition to the quantitative variables noted above, there are some qualitative variables to consider in choosing among JEIM alternatives. These include responsiveness of a centralized system to operational needs, possible changes in flightline experience levels if JEIM is separated from flying units, and ensuring smooth wartime transitions if support is centralized for operations in war but not in peace.

Conclusions and Recommendations

For a major theater war, deploying the JEIM for F-15 and F-16 engines to an FOL is too slow. Constructing test cells at potential FOLs could reduce deployment and setup time, but it would also reduce flexibility for expeditionary operations. The study team therefore recommends that the Air Force develop FSLs for wartime support of fighter engines with removal rates similar to those for the F100 engines analyzed. The speed with which FSL repair can begin wartime operations, when coupled with a short pipeline served by assured transportation, is well suited for expeditionary missions. The team emphasizes that F100 JEIM consolidation will require a dedicated, responsive, and substantial intratheater transportation system during a major theater war, particularly during surge operations. Transportation delays will lead to missed sorties.

The low removal rates for the TF-34 make centralization of its intermediate maintenance easier. The team recommends its centralization even to the extent of using CSLs to support major theater wars, although, as a hedge against transportation uncertainties, some TF-34 repair capability might be included in an FSL. ■

This research brief describes work done for RAND's Project AIR FORCE and documented in *Supporting Expeditionary Aerospace Forces: Alternatives for Jet Engine Intermediate Maintenance* by Mahyar A. Amouzegar, Lionel A. Galway, and Amanda Geller, MR-1431-AF, 2002, 102 pp., ISBN 0-8330-3103-1. The report is available from RAND Distribution Services (Telephone: 310-451-7002; toll free 877-584-8642; FAX: 310-451-6915; or email order@rand.org). Abstracts of RAND documents may be viewed at www.rand.org. Publications are distributed to the trade by NBN. RAND® is a registered trademark. RAND is a nonprofit institution that helps improve policy and decisionmaking through research and analysis; its publications do not necessarily reflect the opinions or policies of its research sponsors.

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